in the thickness of the ferromagnetic layer 151, whereby the two layers are coupled more firmly. For example, for the longitudinal bias layer having a laminated structure of NiFe with Ms of 1T and IrMn of 7 nanometers thick, its coercive force is 80 Oe when its thickness is 20 nanometers, but increases up to 160 Oe when its thickness is 10 nanometers. The value of 160 Oe is an effective value in conventional MR heads. Therefore, in the region where the free layer is thin, for example, having a thickness of at most 5 nanometers, it is desirable to employ the longitudinal bias layer of the type of ferromagnetic layer/antiferromagnetic layer.

In addition, in the longitudinal bias layer of the type of ferromagnetic layer 151/antiferromagnetic layer 152, it is further desirable that the saturation magnetization of the ferromagnetic layer 151 is nearly comparable to or larger than that of the free layer in order to completely remove the Barkhausen noise in a smallest possible longitudinal bias field. The ferromagnetic film 151 may be of an NiFe alloy, but is more preferably of an NiFeCo alloy, a CoFe alloy, Co or the like having a larger saturation magnetization. If a film having a small saturation magnetization is used for the ferromagnetic film 151 and if the Barkhausen noise is removed by increasing its thickness to enlarge the stray magnetic field, the reproduction output will lower especially in narrow track width.

In Fig. 17, the longitudinal bias layers are formed without completely removing the entire spin valve film. Apart from the illustrated case, even the underlayer 141 may be removed through etching. However, in order to maintain good crystallinity of the ferromagnetic layer, it is desirable that the etching depth before the formation of the longitudinal bias layers is at most above the underlayer 142 so as to take advantage of the crystallinity-improving effect of the layer 142. From the viewpoint of film thickness control, it is desirable that the thicker antiferromagnetic layer 143 is etched in some degree and thereafter the magnetic coupling bias is attenuated so as to obtain, longitudinal bias layers having good hard magnetic properties. As the case may be, after the nonmagnetic spacer layer is partly etched, and a longitudinal bias layers of ferromagnetic film 151/antiferromagnetic film 152 may be formed thereover. For the purpose of improving the crystallinity or for the purpose of attenuating the magnetic coupling between the pinned magnetic layer or the antiferromagnetic layer 143 and the longitudinal bias layer, an extremely thin underlayer 153, like the underlayer 143, may be provided below the ferromagnetic film 151. For the purpose of minimizing the reduction in the magnetic coupling between the free layer and the longitudinal bias layer, the thickness of the underlayer 153 is preferably at most 10 nanometers.

Where the hard magnetic film is employed, it is also

desirable that the saturation magnetization of the free layer is comparable to that of the hard magnetic layer. In general, however, it is difficult to prepare a hard magnetic film having high saturation magnetization that is comparable to the free layer of CoFe or the like generally having high saturation magnetization. For this, effective is a method of using a subbing film of FeCo or the like having high saturation magnetization for the hard magnetic film to thereby keep the good balance of saturation magnetization between the subbed hard magnetic film and the free layer, for the purpose of removing the Barkhausen noise in a small longitudinal bias magnetic field.

For the antiferromagnetic film 152, employable is the same antiferromagnetic substance as that for the spin valve film. However, the magnetic coupling bias field for the antiferromagnetic layer in the spin valve film is in the height direction while that for the antiferromagnetic film 152 in the longitudinal bias layer is in the track width direction, or that is, the two must be perpendicular to each other. Therefore, for example, the two are made to have a different blocking temperature Tb, and the magnetic coupling bias direction of the antiferromagnetic layer having a higher Tb is first settled through thermal treatment, and thereafter the antiferromagnetic film having a lower Tb is subjected to thermal treatment at lower temperatures. In that condition,